Project Work Written Report

Category 8

Every Little Drop COUNTS

Group 8-17

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1 INTRODUCTION

1.1 Background Information

Firstly, we chose to do our project on Data Analysis of water usage, because we hope to make conservation of water our way of life.

However, we are unable to find enough data for Singapore (due to PUB being US centric and having largely unpublished data). Thus, we will analyse data from the United States of America (USA) because of the availability of data. The country is similar to Singapore as it is also an advanced developed nation. Also, the US is big with many states and cities, hence it is easier for us to focus on cities with different demographics to make our analysis meaningful. We will be analysing specific states such as Washington, Texas, Florida, California, etc, to compare to Singapore.

1.2 Objectives

The objective of our project is to analyse water usage in the US to find out how it is affected by factors such as the types of water use and urbanisation. Thus, we can estimate whether Singapore uses much water, and if so, create suggestions on how to reduce water usage in Singapore.

1.3 Research Questions

1) What is the water consumption pattern across the different states in US?

2) How does water consumption for different types of neighbourhoods and households (Urban, Suburban, Rural) differ?

3) How does water consumption for different types of uses (agricultural, industrial) differ?

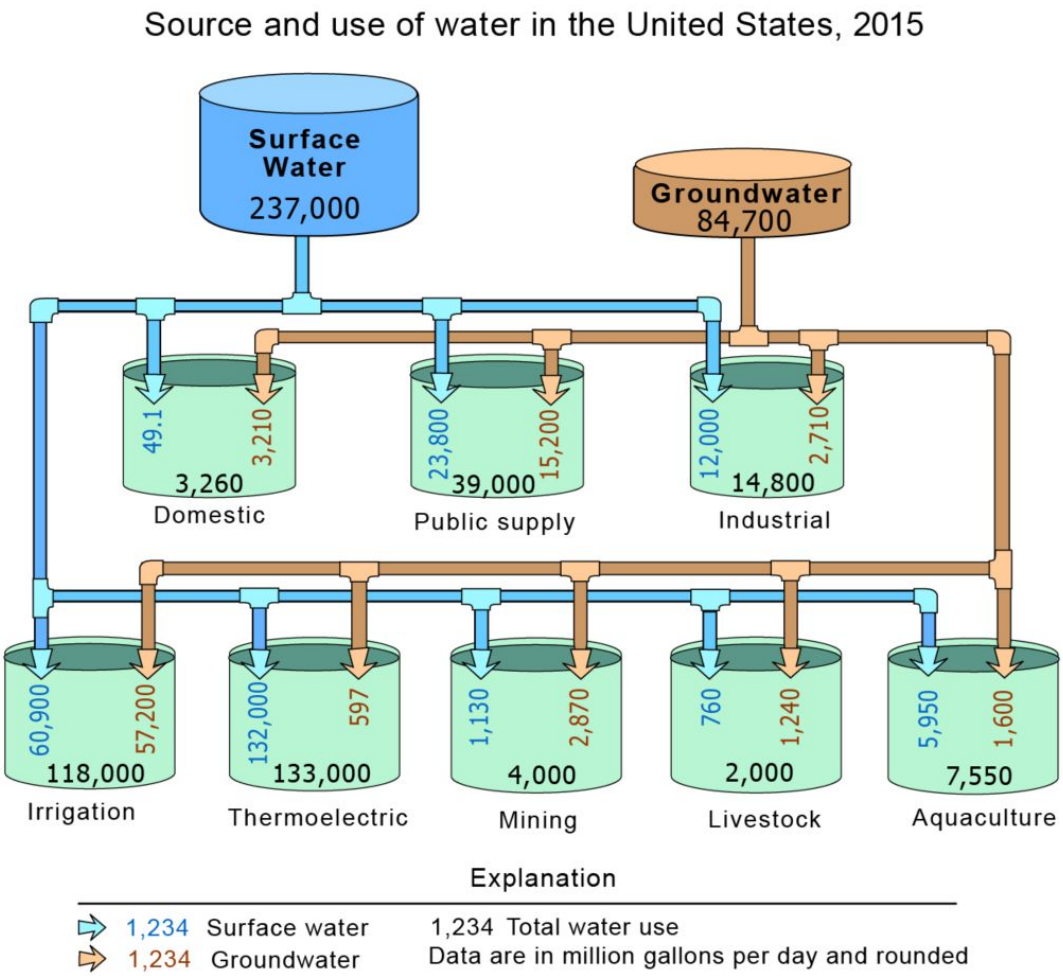
2 LITERATURE REVIEW

2.1 Literature Review

Different uses of water, Retrieved from:

https://www.usgs.gov/special-topic/water-science-school/science/total-water-use-united-states?qt-science_center_objects=0#qt-science_center_objects

This infographic shows a general overview of how water uses vary in the US.

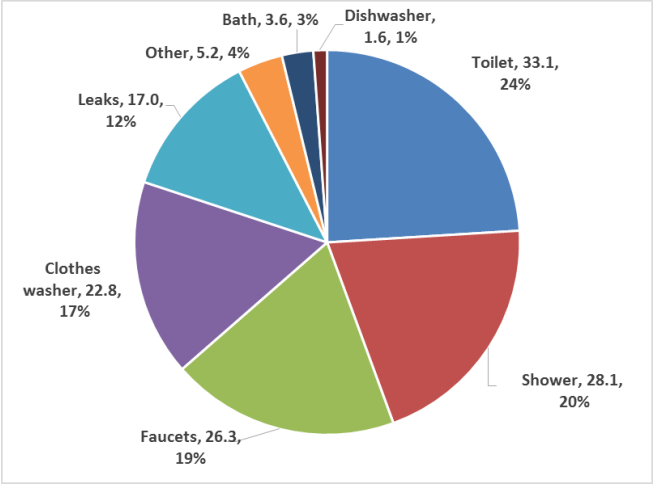


DeOreo, W.B.; Residential End Uses of Water, Version 2. Domestic water uses in US.

Retrieved from:

https://www.usgs.gov/mission-areas/water-resources/science/domestic-water-use?qt-science_center_objects=0#qt-science_center_objects

This infographic shows a general overview of how domestic water use varies in the US.

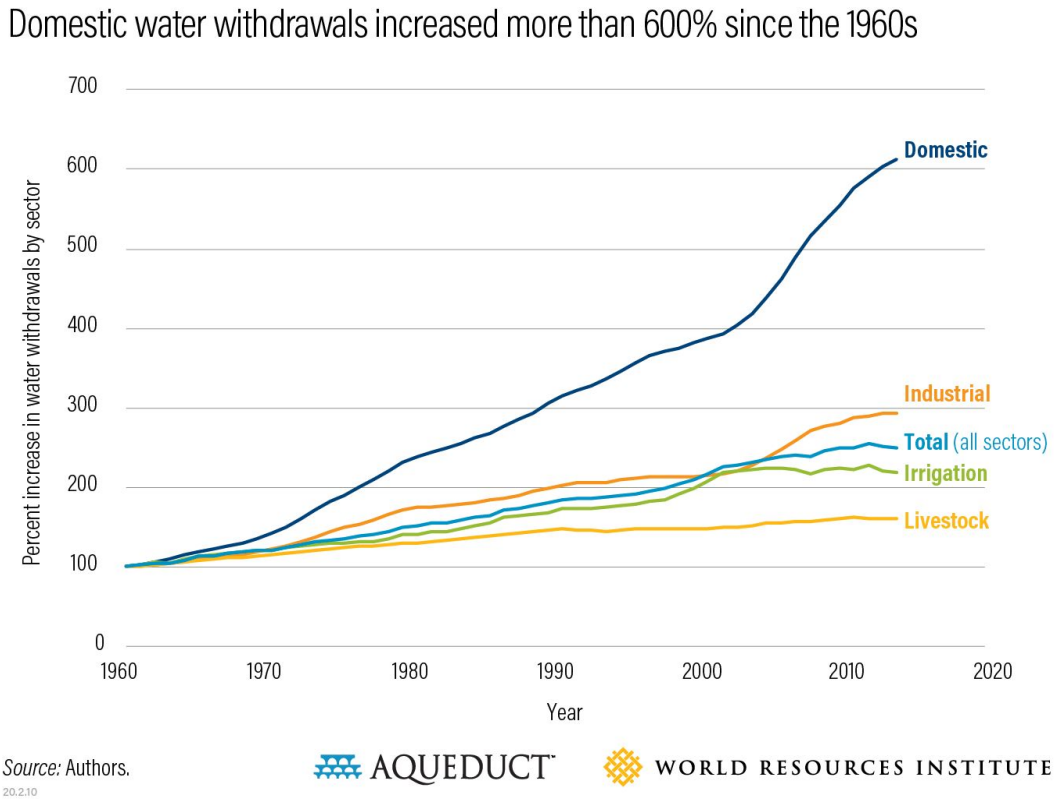


Otto, B. Schleifer, L. (2020, February 10) Trends of water uses in US.

Retrieved from:

https://www.wri.org/blog/2020/02/growth-domestic-water-use

This infographic shows the trends of water withdrawals in the US.



Brown, T.C. (1999, September) Trends between water uses.

Retrieved from:

https://www.fs.fed.us/rm/pubs/rmrs_gtr039.pdf

This shows the average trends of water usages.

US water withdrawals in 20th century

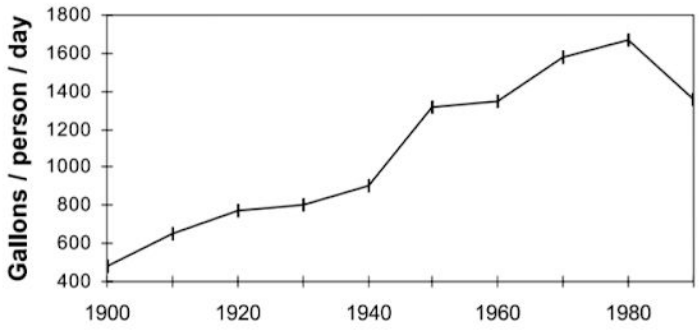


Figure 4. Total withdrawal per capita, 1900 to 1990.

US water usage in 20th century

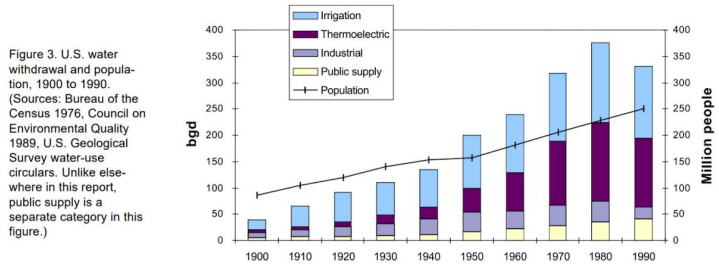


Figure 3. U.S. water withdrawal and population, 1900 to 1990. (Sources: Bureau of the Census 1976, Council on Environmental Quality 1989, U.S. Geological Survey water-use circulars. Unlike elsewhere in this report, public supply is a separate category in this figure.)

3 RESULTS AND FINDINGS

3.1 Methodology

We used data analysis.

Coding Software - R Studio

Heatmap Software - Tableau

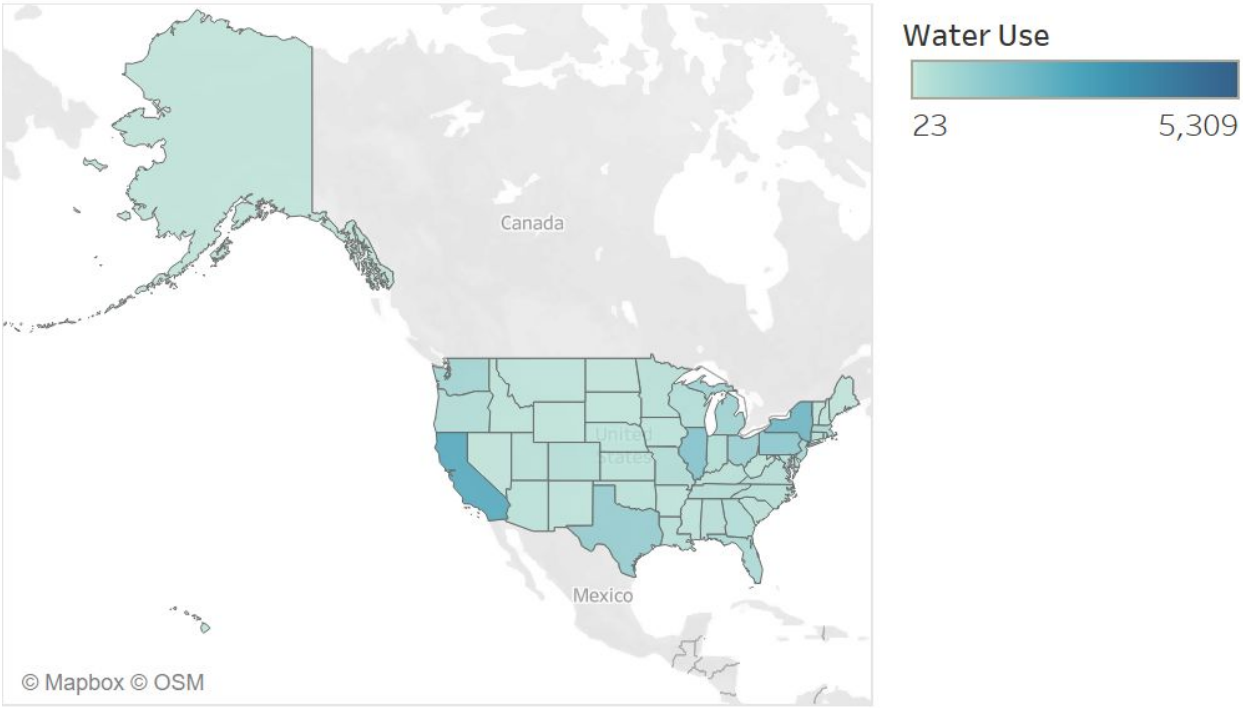
Analysis model - US map

3.2 Research Question 1 Solution

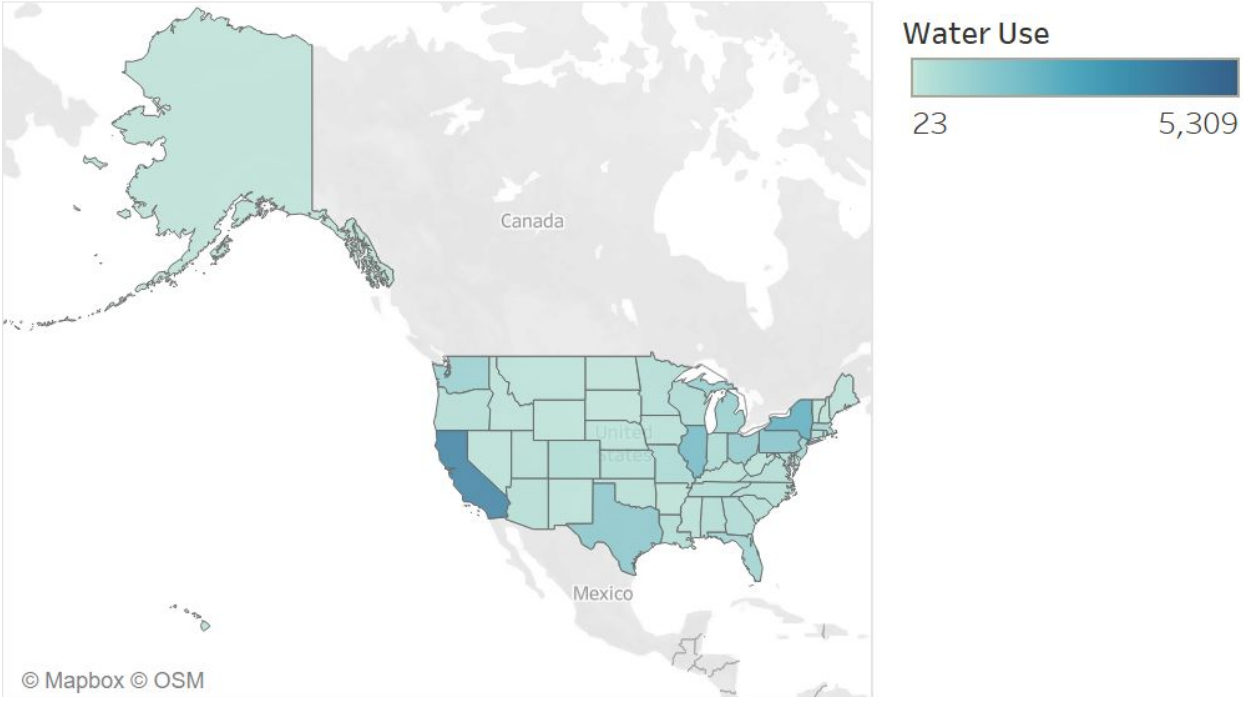
Our first research question was, what is the water consumption pattern across the different states in US?

We managed to find data for domestic, industrial and commercial water use of US, for the years 1960, 1965, 1970, 1975, 1980, 1985 and 1995. We then used the Tableau software to create heatmaps of US' water usage for each of those years.

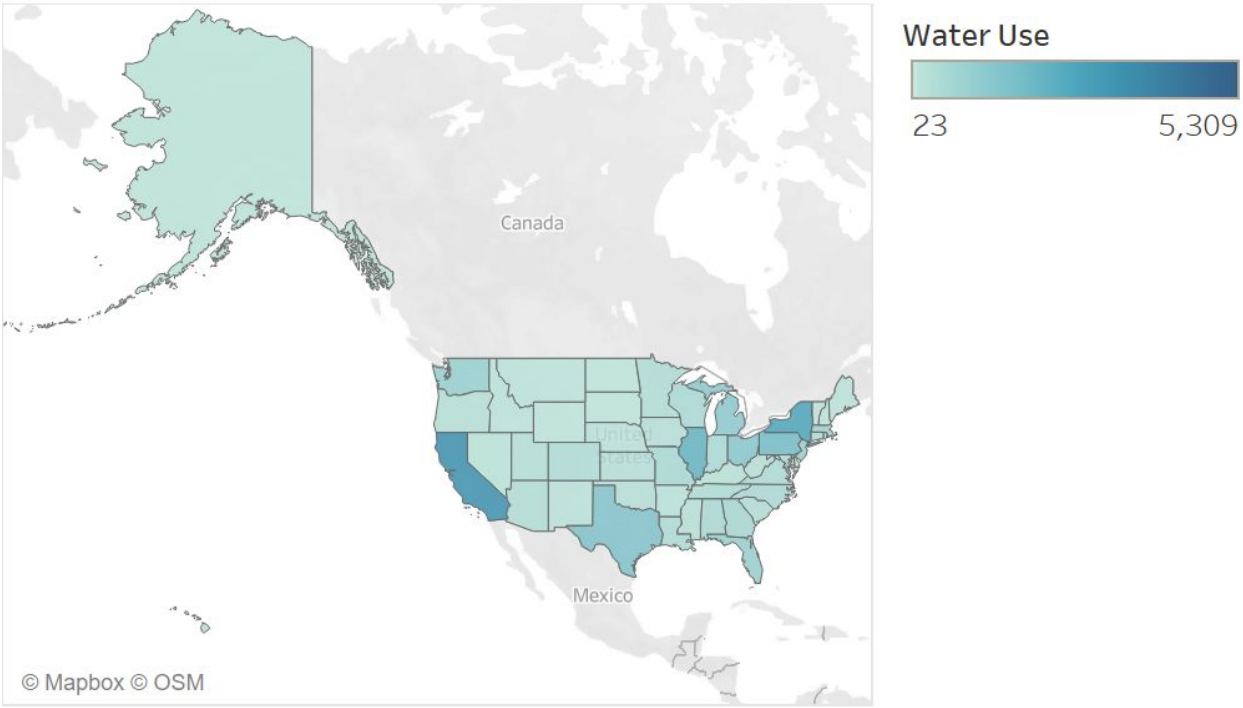
Data - 1960



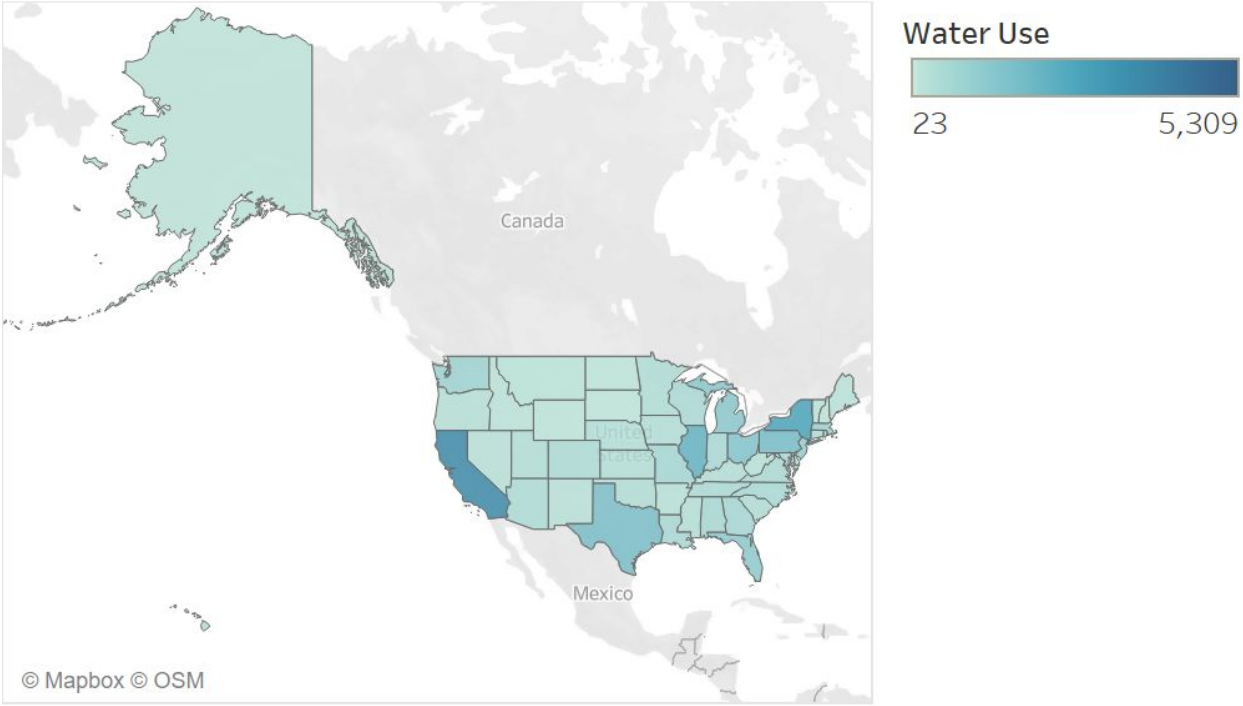
Data - 1965



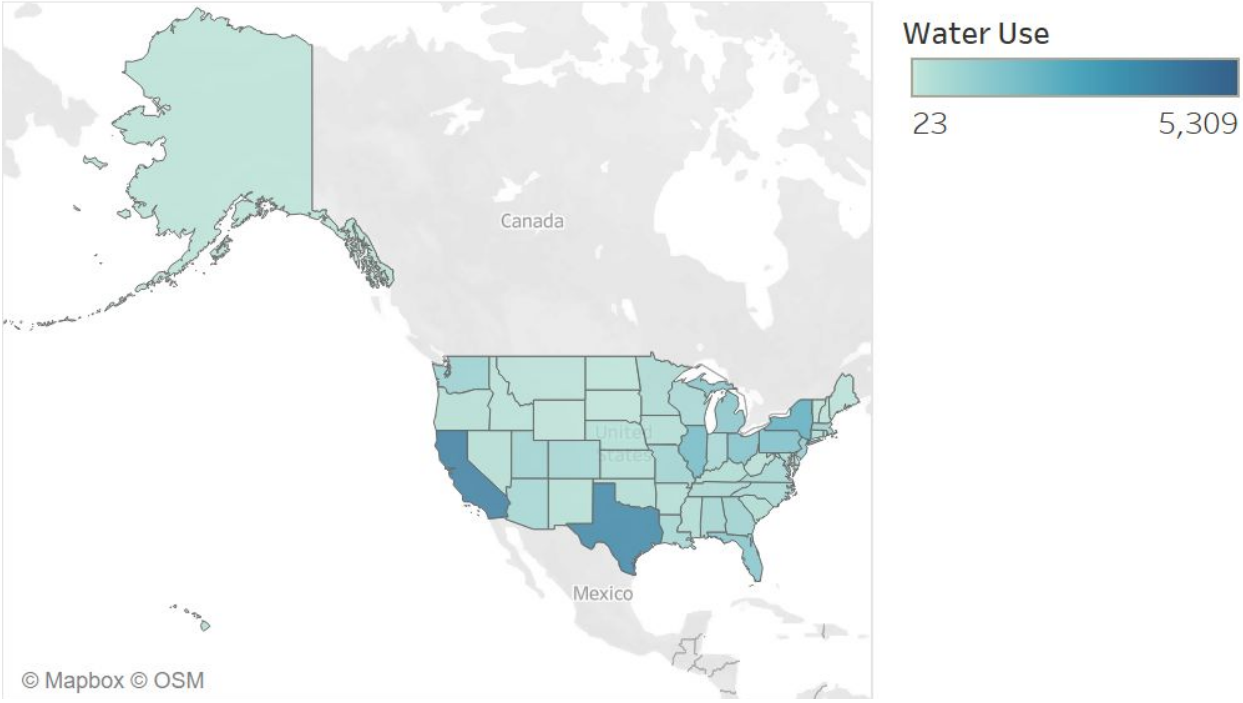
Data - 1970



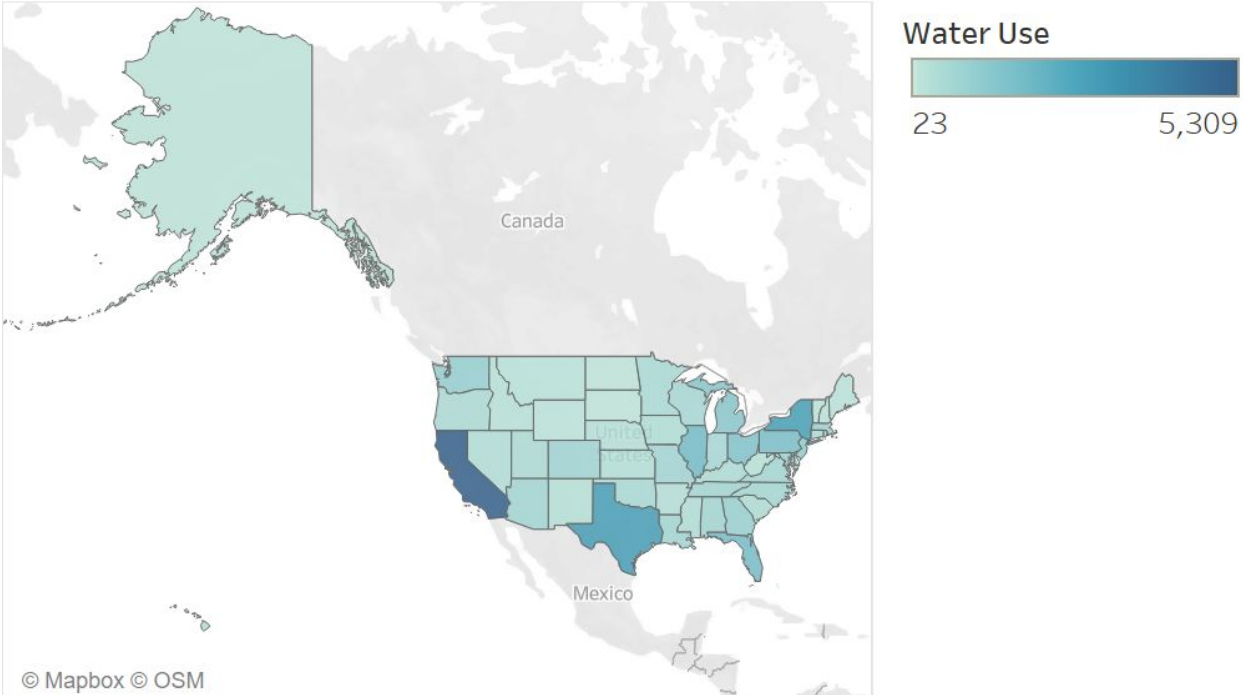
Data - 1975

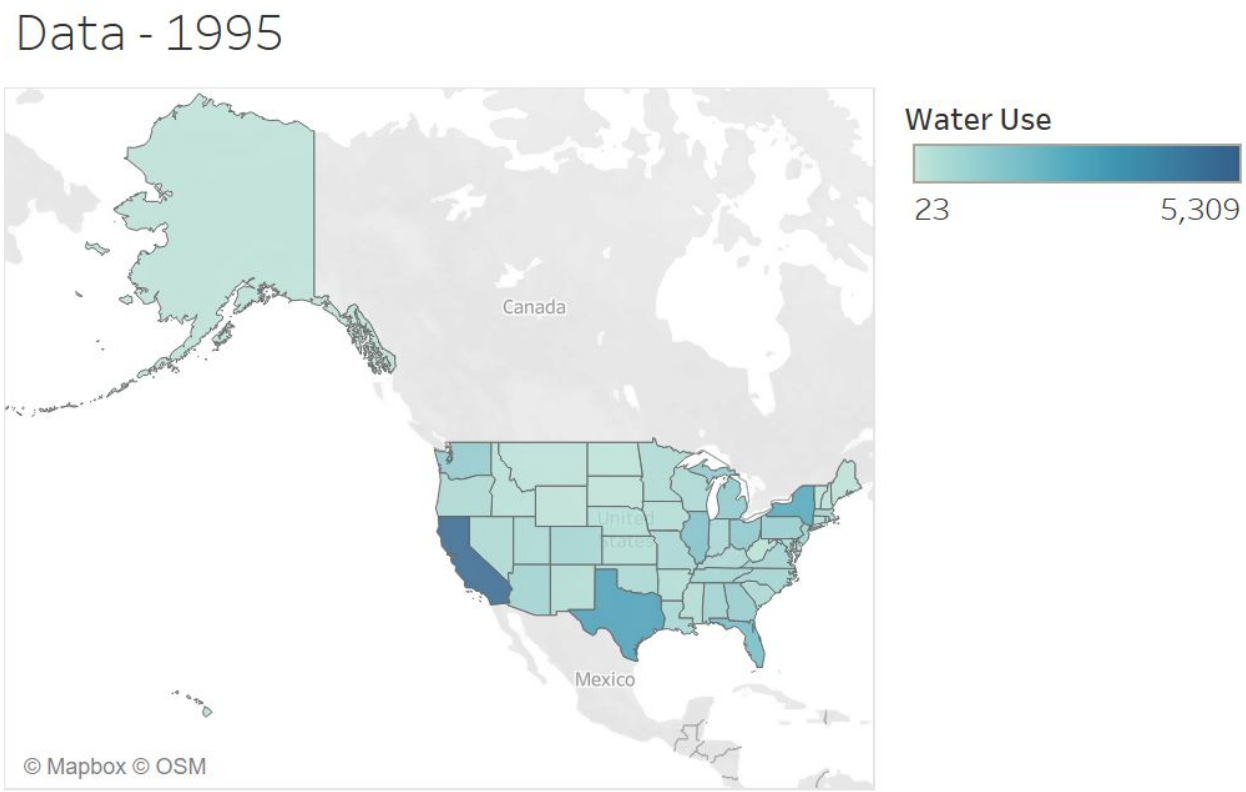


Data - 1980



Data - 1985

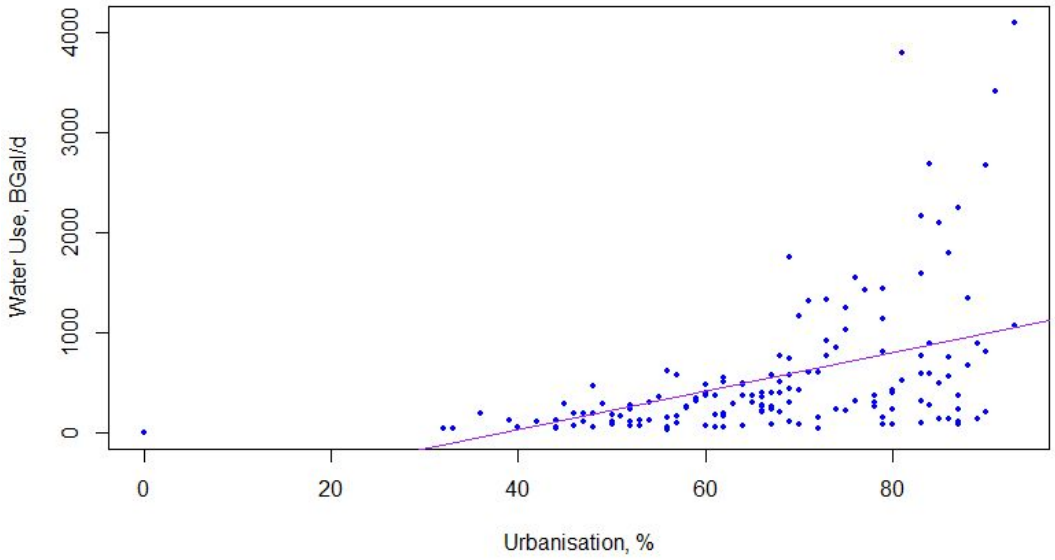




3.3 Research Question 2 Solution

Our second research question was, how does water consumption for different types of neighbourhoods and households (Urban, Suburban, Rural) differ?

We already had data for the water use of all states for the years 1960, 1965, 1970, 1975, 1980, 1985 and 1995. We then found data that showed how urban the states of US were every decade. Thus, we managed to use that data to plot a graph, and create a best fit line, to show how urbanisation affects the use of water in a state.



We found that when urbanisation increases by 1%, water use increases by 19.23503 BGal/d on average.

Countries with a higher urbanisation percentages have both high and low water uses. However, countries with lower urbanisation percentages tend to have mostly low water uses.

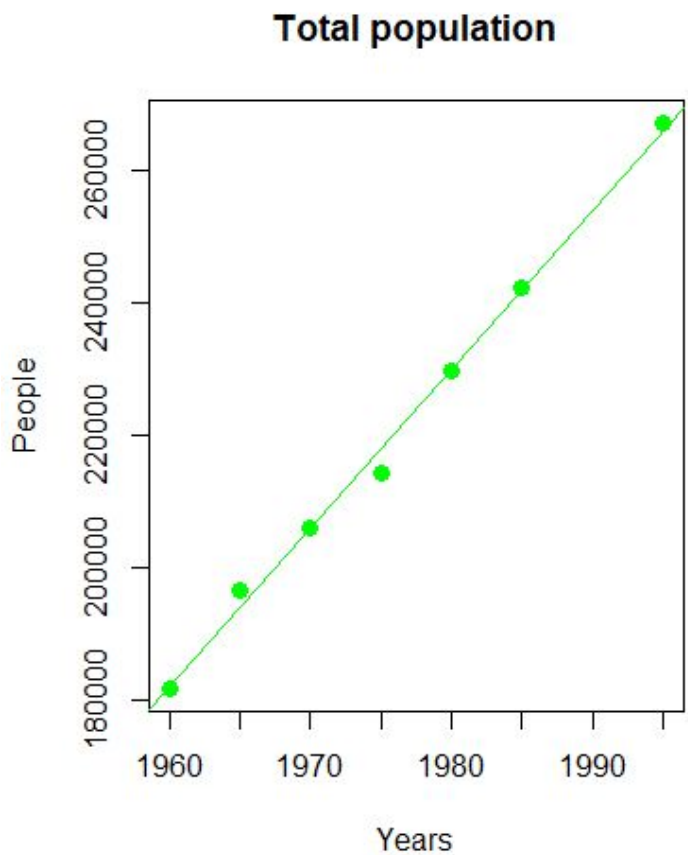
This may be due to countries with lower urbanisation having less people, so less products and services are required, that may require water to manufacture. There will also be less factories, so the water use will be low. However, countries with high urbanisation will could use more products and services which require water, however the state may be more affluent and technologically advanced, and have more products or services that save water, thus the water use may be high or low depending on the state.

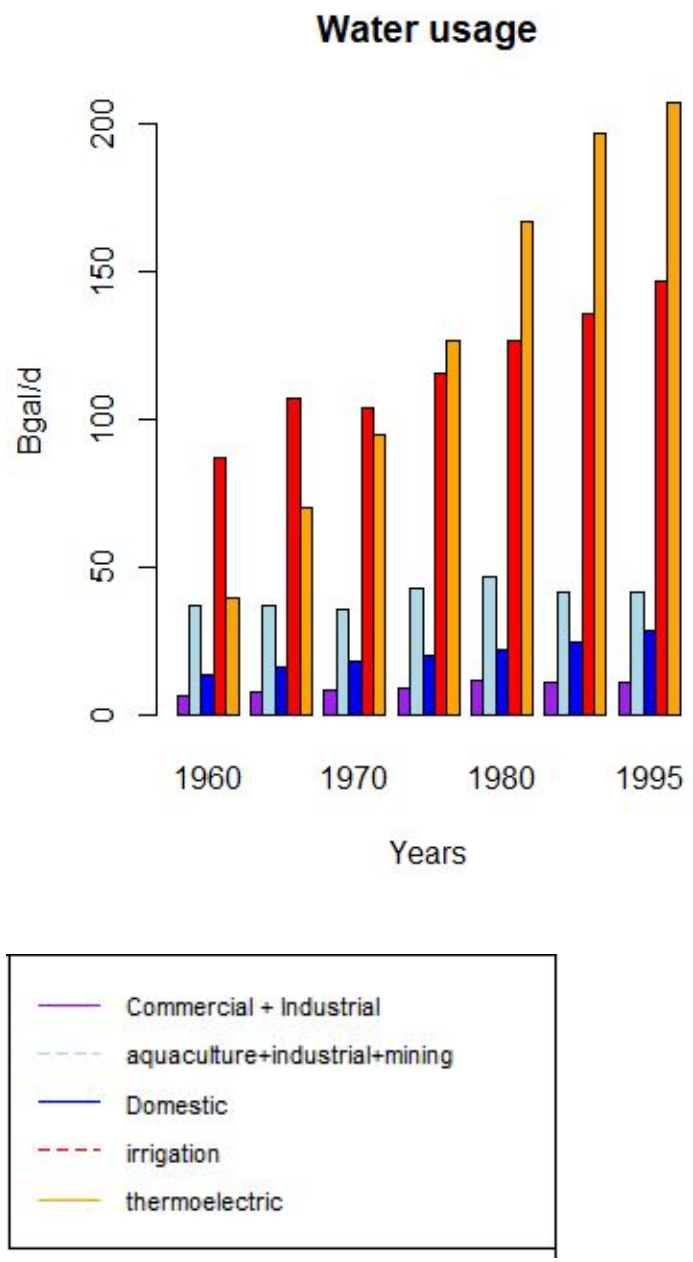
More urban states like California, Texas and New York tend to have a higher water consumption than rural/suburban states, like North Dakota, Maine and New Mexico, as seen on the heatmap. This may be due to the increasing population and affluence, which would increase the water usage and allow each person to use more water.

3.4 Research Question 3 Solution

Our third research question is, how does water consumption for different types of uses (agricultural, industrial) differ?

We managed to find data for US' total population and water use for Comercial, Industrial, Aquaculture, Mining, Domestic, Irrigation and Thermoelectric purposes, for the years 1960, 1965, 1970, 1975, 1980, 1985 and 1995. From this, we created graphs to show the trend of US' total population and water uses, as shown below.




Water usage
Bgal/d
0
50
100
150
200
1960
1970
1980
1995
Years
Commercial + Industrial
aquaculture+industrial+mining
Domestic
irrigation
thermoelectric

We found out that the population in US tends to increase at approximately 2404741 people per 5 years.

The water usage for Commercial and Industrial purposes tend to increase at approximately 0.1510586 billion gallons per 5 years.

The water usage for Aquaculture, Industrial and Mining purposes tend to increase at approximately 0.2571429 billion gallons per 5 years.

The water usage for Domestic purposes tend to increase at approximately 0.418356 billion gallons per 5 years.

The water usage for Irrigation purposes tend to increase at approximately 1.864286 billion gallons per 5 years.

The water usage for Thermoelectric purposes tend to increase at approximately 5.907143 billion gallons per 5 years.

3.5 Suggestions

Since Singapore is a smaller country, its urbanisation is considerably higher. Comparing it to states in the US with high urbanisation percentages, Singapore likely uses more water per person.

However, Singapore does not use water for irrigation, as it is a small country with not much space. Comparing it to the states in US which are very similar, those states uses much water for irrigation, since Singapore is a smaller country, it may not use that much water.

Although Singapore may not use as much water as some states in the US, Singaporeans should definitely put in effort to reduce their water usages.

Some suggestions for reducing water usage are, the government can paste posters in public areas, or have schools to teach students about the importance of reducing water and how to reduce water, so that Singaporeans will have more efficient usage of water.To reduce water, Singaporeans can have shorter showers and use a mug to

rinse their mouth when brushing their teeth. The government can also try to cut down water wastages in industry and use water more effectively.

4 CONCLUSION

4.1 Limitations

The data available were limited, and in intervals of around 5 years. Therefore some of the data could be outdated and irrelevant today.

There was no data available for water use per person in the US, only total water use, which may cause the results to be less accurate.

4.2 Acknowledgements

We would like to thank our project mentor, Mrs Chua Ee Ling, who has guided us through the course of this entire project. She has helped point us in the right direction on several occasions so we know what we need to keep doing. We also want to thank Ms Chua Hui Xiang, for her insightful and valuable feedback to help us improve. Next, we want to thank the judges for their time and effort to read our reports and grade us. In addition, we would like to thank Hwa Chong Institution for giving us this opportunity to work on this research project.

4.3 References

https://water.usgs.gov/watuse/data

https://www.census.gov/prod/cen2010/cph-2-1.pdf

4.4 Appendix

The following is the code that we used to plot all the graphs.

```
#Data sources

setwd("C:/Users/John/Downloads/PW 2020 data/Water Usage/These are those
files converted into CSV so i can use them")

a<-read.csv("a.csv",header=T)

b<-read.csv("b.csv",header=T)

c<-read.csv("c.csv",header=T)

d<-read.csv("d.csv",header=T)

e<-read.csv("e.csv",header=T)

f<-read.csv("f.csv",header=T)

g<-read.csv("g.csv",header=T)

a2<-read.csv("a2.csv", header=T)

b2<-read.csv("b2.csv", header=T)

c2<-read.csv("c2.csv", header=T)

d2<-read.csv("d2.csv", header=T)

e2<-read.csv("e2.csv", header=T)
```

```
#Data points

y <- c(1960, 1965, 1970, 1975, 1980, 1985, 1995)

pop = c(sum(a2$TP.TotPop), sum(b2$TP.TotPop), sum(c2$TP.TotPop),
sum(d2$TP.TotPop), sum(e2$TP.TotPop), 242351.16, sum(g$TotalPop))

dom = c(sum(a$PSDelDP), sum(b$PSDelDP), sum(c$PSDelDP),
sum(d$PSDelDP), sum(e$PSDelDP), 20959.74 + 4042.66, sum(g$PSDelDO) +
sum(g$PSUsLos)) / 1000

com = c(sum(a$PS.DelCI), sum(b$PS.DelCI), sum(c$PS.DelCI),
sum(d$PS.DelCI), sum(e$PS.DelCI), 5711.92 + 5733.12, sum(g$PS.DelCO) +
sum(g$PS.DelIN)) / 1000

y2 <- c(1950, 1955, 1960, 1965, 1970, 1975, 1980)

aquaculture <- c(37, 37, 36, 43, 47, 42, 42)

irrigation <- c(87, 107, 104, 116, 127, 136, 147)

thermoelectric <- c(40, 70, 95, 127, 167, 197, 207)

#Graphs

par(mfrow=c(1, 1))

#Left graph
```

```
plot(y, pop, pch = 16, cex = 1.3, col = "white", main = "Total population", xlab =
"Years", ylab = "People")

points(y, pop, pch = 16, cex = 1.3, col = "green")

abline(g1 <- lm(pop ~ y), col = "green")

#Right graph

plot(c(1900, 2150), c(0, 250), pch = 16, cex = 1.3, col = "white", main = "Water
usage", xlab = "Years", ylab = "Bgal/d")

points(y, dom, pch = 16, cex = 1.3, col = "blue")
points(y, com, pch = 16, cex = 1.3, col = "purple")
points(y2, aquaculture, pch = 16, cex = 1.3, col = "light blue")
points(y2, irrigation, pch = 16, cex = 1.3, col = "red")
points(y2, thermoelectric, pch = 16, cex = 1.3, col = "orange")

abline(g2 <- lm(dom ~ y), col = "blue")
abline(g3 <- lm(com ~ y), col = "purple")
abline(g4 <- lm(aquaculture ~ y2), col = "light blue")
abline(g5 <- lm(irrigation ~ y2), col = "red")
```

```
abline(g6 <- lm(thermoelectric ~ y2), col = "orange")


lines(plot.dim[3,], com+aquaculture+dom+irrigation+thermoelectric)

coef(g1)

coef(g2)

coef(g3)

coef(g4)

coef(g5)

coef(g6)


legend("topright", legend=c("Commercial + Industrial",
"aquaculture+industrial+mining", "Domestic", "irrigation", "thermoelectric"), col =
c("purple", "light blue", "blue", "red", "orange"), lty=1:2, cex=0.7)


#Graph 3


x <- rbind(com, aquaculture, dom, irrigation, thermoelectric)

plot.dim <- barplot(x, beside = TRUE, names.arg=y, col = c("purple", "light blue",
"blue", "red", "orange"), main = "Water usage", xlab = "Years", ylab = "Bgal/d")


#RQ 1


use = matrix(nc = 51, nr=9)
```

```
for (i in 1:51) use[1, i] = a[i, 1]
for (i in 1:51) use[2, i] = a[i, 6] + a[i, 7]
for (i in 1:51) use[3, i] = b[i, 6] + b[i, 7]
for (i in 1:51) use[4, i] = c[i, 6] + c[i, 7]
for (i in 1:51) use[5, i] = d[i, 6] + d[i, 7]
for (i in 1:51) use[6, i] = e[i, 6] + e[i, 7]
for (i in 1:51) use[7, i] = 0

for (i in 1:51){

  f3 = f$ps.deliv[f$scode == use[1, i]]
  use[7, i] = sum(f3[1:length(f3) - 1])

}

for (i in 1:51) use[8, i] = 0
for (i in 1:51) use[8, i] = sum(g$PS.DelTO[g$StateCode == use[1, i]])
use

i = 1

states = c("Alabama", "Alaska", "American Samoa", "Arizona", "Arkansas",
"Baker Island", "California", "Colorado", "Connecticut", "Delaware", "District of
Colombia", "Florida", "Federated States of Micronesia", "Georgia", "Guam",
```

"Hawaii", "Howland Island", "Idaho", "Illinois", "Indiana", "Iowa", "Jarvis Island", "Johnston Atoll", "Kansas", "Kentucky", "Kingman Reef", "Louisiana", "Maine", "Marshall Islands", "Maryland", "Massachusetts", "Michigan", "Midway Islands", "Minnesota", "Mississippi", "Missouri", "Montana", "Navassa Island", "Nebraska", "Nevada", "New Hampshire", "New Jersey", "New Mexico", "New York", "North Carolina", "North Dakota", "Northen Mariana Islands", "Ohio", "Oklahoma", "Oregon", "Palau", "Palmyra Atoll", "Pennsylvania", "Puerto Rico", "Rhode Island", "South Carolina", "South Dakota", "Tennessee", "Texas", "U.S. Minor Outlying Islands", "Utah", "Vermont", "Virginia", "Virgin Islands of the US", "Wake Island", "Washington", "West Virginia", "Wisconsin", "Wyoming")

```
no = c(1, 2, 60, 4, 5, 81, 6, 8, 9, 10, 11, 12, 64, 13, 66, 15, 84, 16, 17, 18, 19, 86, 67, 20, 21, 89, 22, 23, 68, 24, 25, 26, 71, 27, 28, 29, 30, 76, 31, 32, 33, 34, 35, 36, 37, 38, 69, 39, 40, 41, 70, 95, 42, 72, 44, 45, 46, 47, 48, 74, 49, 50, 51, 78, 79, 53, 54, 55, 56)


for (i in 1:51){

  for (j in 1: length(no)){


    if (as.integer(use[1, i]) == no[j]) use[9, i] = states[j]


  }

}


write.csv(t(use), "C:/Users/John/Downloads/PW 2020 data/Water Usage/These are those files converted into CSV so i can use them/hello.csv")


urban <- read.csv("Urbanisation.csv",header=T)
```

```
urban2 = rep(0, 153)

use2 = rep(0, 153)


count = 0;


for (i in 1:3){

  for (j in 6:57){

    for (k in 1:51){

      if (paste(urban[j, 1]) == use[9, k]){


        count = count + 1;

        urban2[count] = as.integer(sub("%", "", urban[j, 7-i]));

        use2[count] = use[i*2, k];


      }

    }

  }

}


plot(urban2, use2, pch = 16, cex =0.5, col = "blue", xlab = "Urbanisation, %", ylab
= "Water Use, BGal/d")

abline(g7 <- lm(use2 ~ urban2), col = "purple")

coef(g7)
```